A350
TECHNICAL TRAINING MANUAL
MAINTENANCE COURSE - T1+T2 - RR Trent XWB
Auto Flight System (AFS)

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AUTO FLIGHT SYSTEM (AFS)

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AUTO FLIGHT SYSTEM (AFS) DESCRIPTION (2/3)

Flight Guidance and Envelope System

The Flight Guidance and Envelope System (FGES) is hosted in each PRIMary flight control Computer (PRIM).
The FGES functions related to the A/C control are as follows:
- Flight Envelope (FE)
- Autopilot (AP)
- Flight Director (FD)
- Autothrust (A/THR).

Each PRIM includes two channels (side A and side B) that give command/monitor functions. The two channels must operate to do the PRIM functions.
The FE functions are:
- Computation of the characteristic speed
- Detection of abnormal configurations
- Detection of reactive windshear
- Estimation of the weight and Center of Gravity (CG).

The FE gives the commands to the Braking Control System (BCS) for a maximum braking if there is a runway overrun detection and/or to tell the crew there is a runway overrun (Brake to Vacate (BTV)).
The AP function gives the orders as follows:
- Position of the control surfaces on the three axes (pitch, roll, yaw)
- Steering of the nose landing-gear wheels (auto-roll out function) through the Wheel Steering Control System (WSCS).

The WSCS does the A/C lateral control through the nose-wheel steering.
The FD functions give guidance orders used in manual control mode. These orders are shown on the PFDs.
The A/THR controls the engine-thrust target N1 through the Propulsion Control System (PCS) system related to the position of the throttle control levers.
The Flight Control Unit (FCU) and the EFIS control panels are used to:
- Engage or disengage the Automatic Flight System (AFS) functions
- Select the mode.

The PRIMs:
- Do the computations (engagements, modes, targets)
- Send back the data to be shown (green lights, modes, targets) to the AFS control panel for the FCU only.

There are two EFIS/FCU backup applications hosted in two CPIOMs of type J. They transmit the auto-flight orders of the flight crew if there is a failure of a FCU or EFIS control panel.
The primary sensors are the Air Data/Inertial Reference System (ADIRS) and NAV sensors.
The Flight Guidance (FG) modes are shown in the Flight Mode Annunciator (FMA) area of the PFDs.
The CPIOMs include two Flight Control Data Concentrators (FCDCs). They do the system maintenance and give the warnings, cautions and indications of the AFS and Primary Flight Control System (PFCS). They also have the Weight and Balance Backup Computation (WBBC) function. The WBBC calculates its own estimation of the A/C weight and CG independently of the fuel system. The WBBC is used by the flight control and FG functions as follows:
- To consolidate the fuel system data
- If there is a fuel system failure.

The Flight Management System (FMS) helps the flight crew in navigation and flight preparation. The FMS computes the most efficient flight in fuel and time savings and automatically navigates the A/C. It calculates performance data and the most fuel-efficient route to fly, based on typical A/C parameters such as weight, cruise altitude and actual A/C position. The flight crew uses the Flight Management (FM) functions through the use of the KCCU. FM data are shown on the CDS (for example: FM data are shown through dedicated pages on the MFDs).

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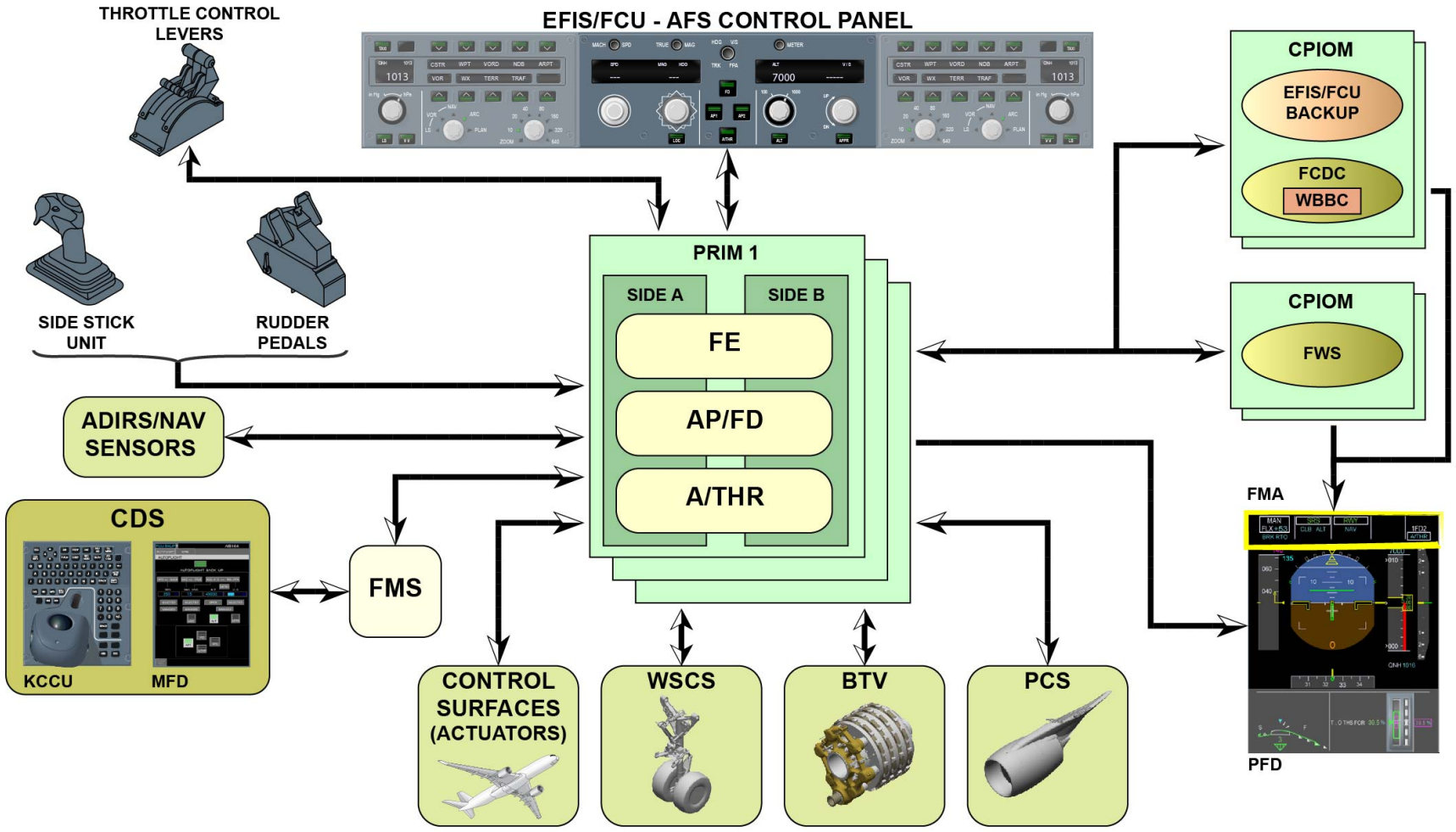

ADIRS: Air Data/Inertial Reference System
AP/FD: Autopilot/Flight Director
A/THR: Autothrust
BTV: Brake to Vacate
FCDC: Flight Control Data Concentrator
FCU: Flight Control Unit
FE: Flight Envelope
FMA: Flight Mode Annunciator
FMS: Flight Management System
PCS: Propulsion Control System
PRIM: PRIMary Computer
WBBC: Weight and Balance Backup Computation
WSCS: Wheel Steering Control System

FLIGHT GUIDANCE AND ENVELOPE SYSTEM

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AUTO FLIGHT SYSTEM (AFS) DESCRIPTION (2/3)

Flight Guidance

The AP/FD guidance orders are computed in the PRIMs in relation to the different inputs received through:
- The ARINC 429 buses (critical data)
- The AFDX network from the applications hosted in the CPIOMs.
These inputs are:
- The characteristic speeds from the FE, internally to the PRIMs
- The mode and target selections from the FCU (or the FCU backup applications hosted in the CPIOM-Js if there is a FCU failure)
- The managed targets from the Flight Management Computers (FMCs) through the AFDX network
- The Air Data/Inertial Reference Units (ADIRUs) and the Integrated Standby Instrument System (ISIS) data. The ISIS sends to the PRIMs some air data parameters used to consolidate the parameters received from the ADIRUs.
- The Slat Flap Control Computers (SFCCs) send the position of the slats, flaps and slat/flap control lever.
- The Multi-Mode Receivers (MMRs) send the ILS and GPS signals for approaches.
- The Traffic Alert and Collision Avoidance System (TCAS), sends orders if there is a resolution advisory, to prevent manual or automatic collision avoidance. When a corrective resolution advisory of the TCAS occurs, it is necessary to start a manoeuver to change the current vertical speed of the A/C. This speed must agree with the TCAS advisory shown on the Vertical Speed Indicator (VSI).
- The LGERS sends the gear position and ground/flight status to give the L/G:
- Status (extension/retraction, gears locked)
- Doors status for characteristic speed computation
- Lever position for Air Data Reference (ADR) which monitors the tuning and characteristic speed computation.
If the AP is not engaged, the FD:
- Engages if it is not already engaged
- Stays engaged, in a vertical mode called TCAS mode. It gives guidance cues in relation to the vertical speed advisory of the TCAS.
If the AP is engaged, the vertical mode reverts to the TCAS mode and does the trajectory deviation in relation to the TCAS vertical speed advisory (FD stays engaged or engages if not already engaged). The crew can always disconnect the AP for the manual maneuver with the FD.
The computed guidance orders are sent from the PRIMs to the PFDs through the AFDX network when the FD is engaged.
The computed guidance orders are internally sent to the PRIMs to the flight control function when the AP is engaged for:
- Automatic deflection of the flight control surfaces
- Automatic nose wheel steering through the AFDX network.
The Side Stick Unit (SSU) and the rudder pedals are locked:
- When the AP is engaged
- If one PRIM requests it.
The PRIM:
- Monitors the hydraulic or AC power sources used by the actuators, computers and sensors of the A/C control surfaces.
- Computes maintenance ground data related to the maintenance phase (low hydraulics and all engines stopped).
The FCDC/WBBC application uses the engine-fuel mass flow from the PCS to compute an estimated weight of the A/C. The two FCDCs send through the AFDX network the backup weight and the backup CG to all the PRIMs.
The overall precision-approach capability (ILS, Global navigation satellite system Landing System (GLS) and satellite landing system) is computed in the FCDC through the data received from each PRIM.
The FCDC acquires signals to know if the DC power sources are segregated. The hydraulic source, AC electric source and DC segregation data are used for the autoland-capability computation.
The PRIM/FCDC transmits some data to the FWS to trigger the AFS and FE warnings, some memos, and some warnings which are not directly

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related to the AFS. These data are sent through the AFDX network and the FCDC. This is not applicable to the AP disconnection warning which is triggered by the FWS, Audio Management System (AMS) and CDS through a hardwired discrete from each PRIM unit.

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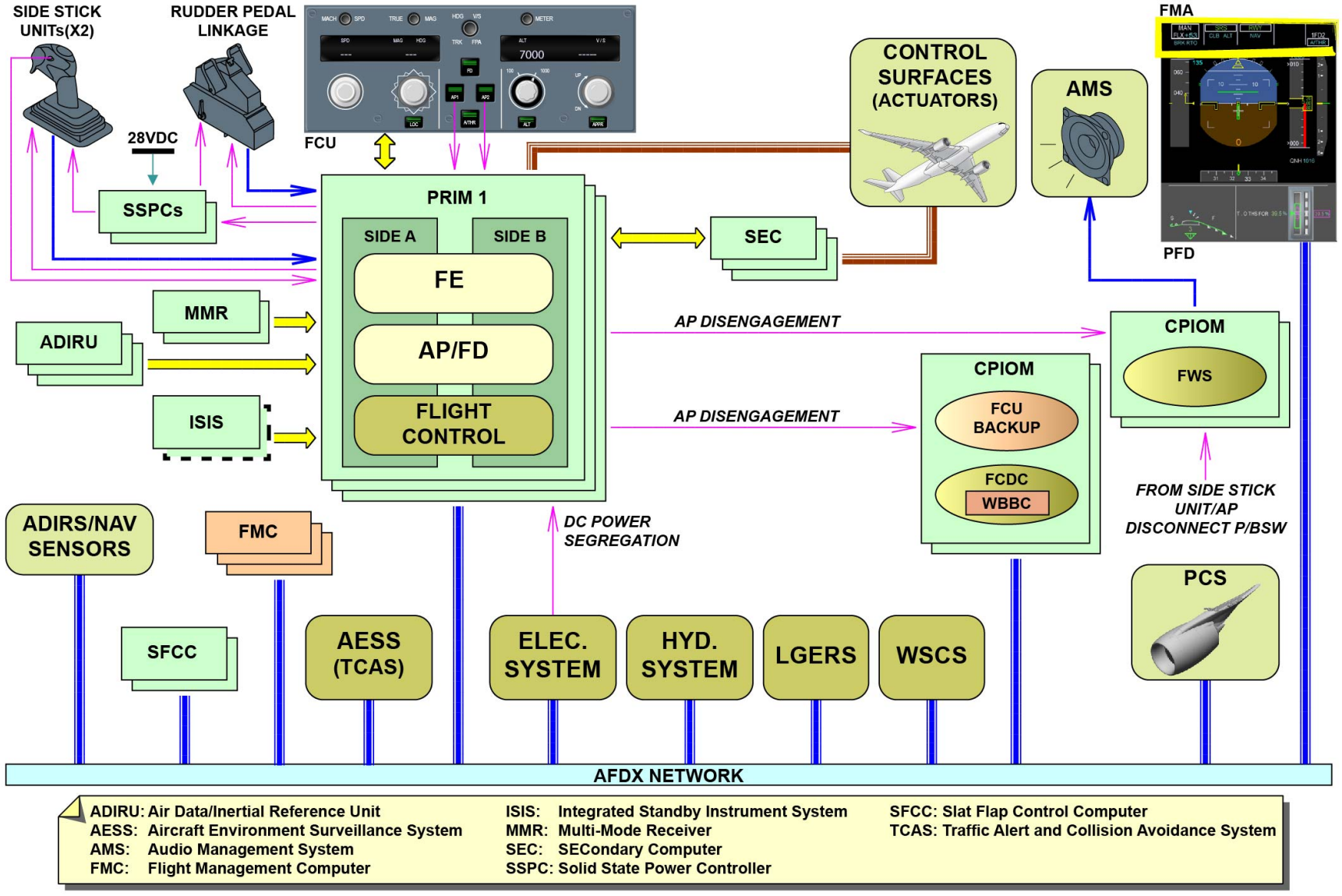

FLIGHT GUIDANCE

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AUTO FLIGHT SYSTEM (AFS) DESCRIPTION (2/3)

Autothrust

The general condition of the A/THR engagement is based on data received from the ADIRUs and LGERS. The PRIMs compute the A/THR target from different inputs.
These inputs are:
- The characteristic speeds and the alpha-floor detection signal from the FE
- The vertical mode from the AP/FD
- The speed/mach mode and the target selection from the FCU (or the FCU backup applications if there is an FCU failure)
- The managed speed/mach target from the FMCs
- The positions of the throttle control levers through analog buses.
- The N1 data (actual, limits) and the engine failure data (for compensation) also from the PCS.

At each TCAS resolution advisory, the A/THR:
- Engages if it is not already engaged
- Stays engaged, in speed mode, with the current A/C speed as a target.

If the TCAS order is not adapted to the A/C performance, the response is the maximum possible in the requested direction. The primary objective is to stay in the normal flight envelope of the A/C and thus prevent AP disengagement during the TCAS alert.
The crew can manually disengage the A/THR as follows. He can:
- Push one of the two A/THR instinctive disconnect P/BSW on the throttle control levers
- Push the A/THR key on the FCU or select the A/THR function on the AFS CP BACKUP page of the MFD
- Set the throttle control levers to the idle position
- Set the two throttle control-levers to the reverse position.

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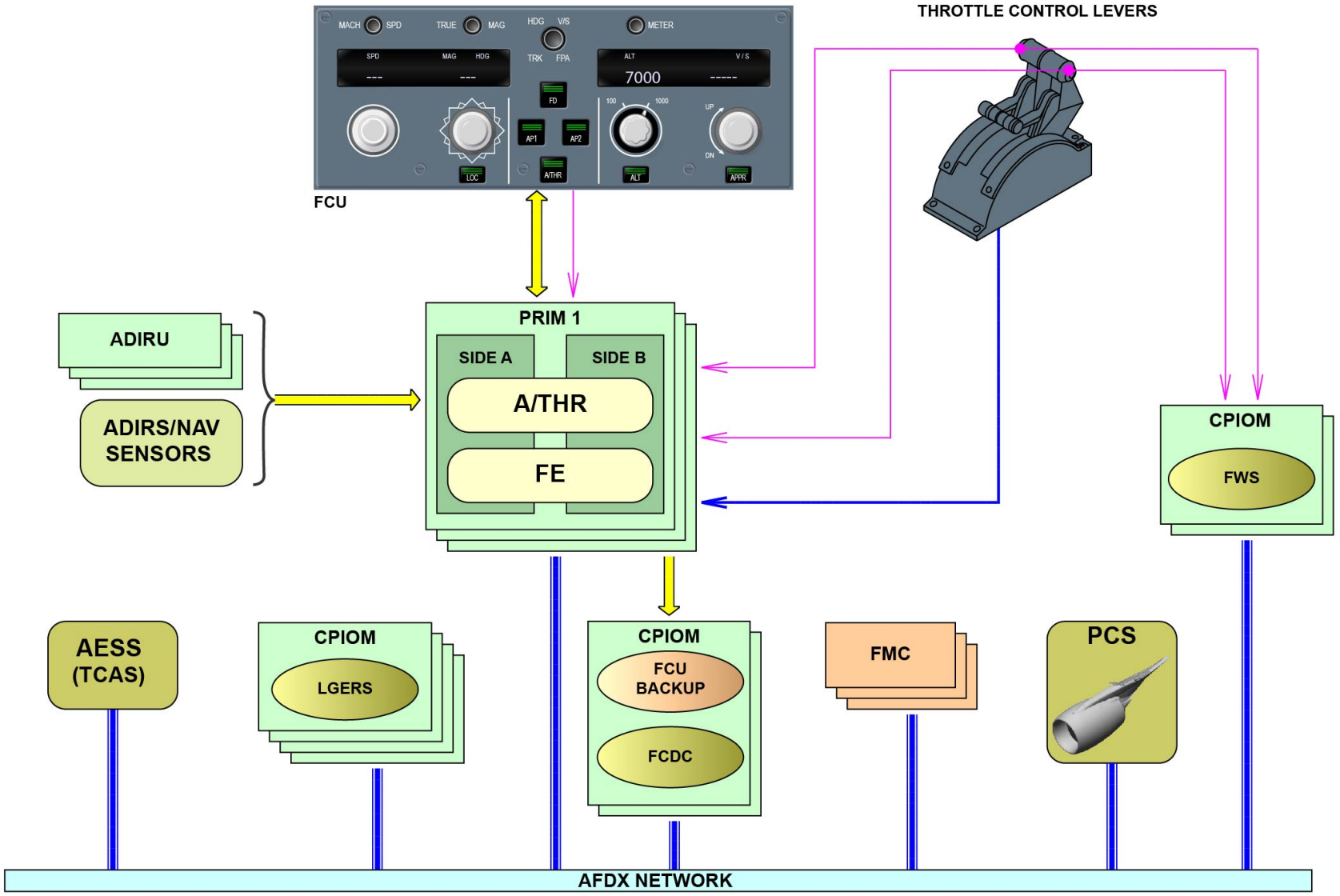
THROTTLE CONTROL LEVERS
FCU
ADIRU
ADIRS/NAV SENSORS
PRIM 1
SIDE A
SIDE B
A/THR
FE
CPIOM
FWS
AESS (TCAS)
CPIOM
LGERS
CPIOM
FCU BACKUP
FCDC
FMC
PCS
AFDX NETWORK

AUTOTHRUST

AUTO FLIGHT SYSTEM (AFS) DESCRIPTION (2/3)

Flight Management System

The FMS does, with the related FMCs, many functions related to the flight planning, navigation (NAV) and performance (PERF) optimization with NAV and PERF Databases (DBs). The FMS functions optimize the Flight Plan (F-PLN) for speed, thrust and altitude (fuel planning and flight time optimization to minimize the flight cost).
The FMS does these primary functions:
- NAV (with related radio tuning, no more A/C position computation but the FMS continues to compute a position (Inertial Reference System (IRS) or IRS/radio)
- F-PLN construction and modification
- Performance calculation and optimization (computation of the trajectory and predictions)
- Guidance (to give the lateral and vertical flight guidance with the guidance modes and targets to fly the active F-PLN)
- FM Human-Machine Interface (HMI) through a display global work-package.

The NAV Database (DB):
- Is used to make the lateral F-PLN with waypoints, radio navigation aids and runways
- Has a worldwide coverage. The DB content is updated every 28 days by the airline who is responsible for it.

The PERF Database (DB):
- Is used to make and optimize the vertical F-PLN with the A/C aerodynamic and engine models.

The KCCUs and the MFDs are used to select, change and monitor the F-PLN.
In addition to the MFD, the FMS lateral and vertical data are shown on the main zone and vertical display of the NDs and also on the PFDs.
The navigation function computes the A/C position estimation and makes an accurate analysis of this computation.
The FMS uses data from the systems that follow:
- The Navigation Aids (NAVAIDs):
- MMR/GPS
- DME
- VOR
- MMR for ILS.
- The ADIRS, which supplies:
- Air data (computed air speed, altitude, vertical speed, mach number, etc.)
- Navigation data (position, ground speed, velocities and accelerations, etc.)
- Attitude data (pitch angle, roll angle, pitch and roll rotation rates, pitch and roll rotation accelerations)
- Heading data (magnetic heading, true heading, yaw rotation rates, etc.)
- Time data.
- The Fuel Quantity and Management System (FQMS) applications.

The FMCs receive the A/C Gross Weight (GW), CG and Fuel On Board (FOB) fuel data from the FQMS applications, hosted in the CPIOMs. These data are sent through the CRDCs, which give path segregation through the AFDX network.
The active FMCs tune the NAVAIDs through the Radio and Audio Management Panels (RMPs).
The FMS ATC function exchanges data with the ATC centers through the ATC data link application and the Avionics Communication Router (ACR).
The FMS AOC function exchanges data with the AOC centers through the ACR. ATC and AOC centers are called operational ground centers.
Data link: FMS ATC
The flight crew can request a F-PLN revision clearance to the ATC center with the FMS ATC function. The ATC center can ask the aircraft to give some parameters (e.g. altitude) immediately or in special conditions (e.g. at 10 am).
Data link: FMS AOC

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The flight crew can request a F-PLN initialization, takeoff or wind data to the AOC center with the FMC ATC function. The request starts from the special pages of the MFDs.
Then, the AOC center will reply with the different data requested by the flight crew. After acceptance, the flight crew can put the received flight initialization data into the active or secondary F-PLN.
The flight crew can print specific data on the printer-1 (e.g.: F-PLN, wind data report).
The FMS data are shown on three Display Units (DUs):
- The center lower DU: MFDs
- The two inner DUs (left/right): PFDs and NDs.

The MFDs show various different data such as the flight plans, PERF data and software P/Ns through the related pages.
The PFDs show various different data such as managed targets (e.g.: speeds: critical engine failure speed (V1), rotation speed (VR), etc.).
The NDs show:
- In the main primary zone: lateral F-PLN, vertical data (e.g.: Top of Climb (T/C) and wind direction, etc.)
- On the vertical display: vertical F-PLN, altitude constraints
- In the FMS dialog window: F-PLN revision data.

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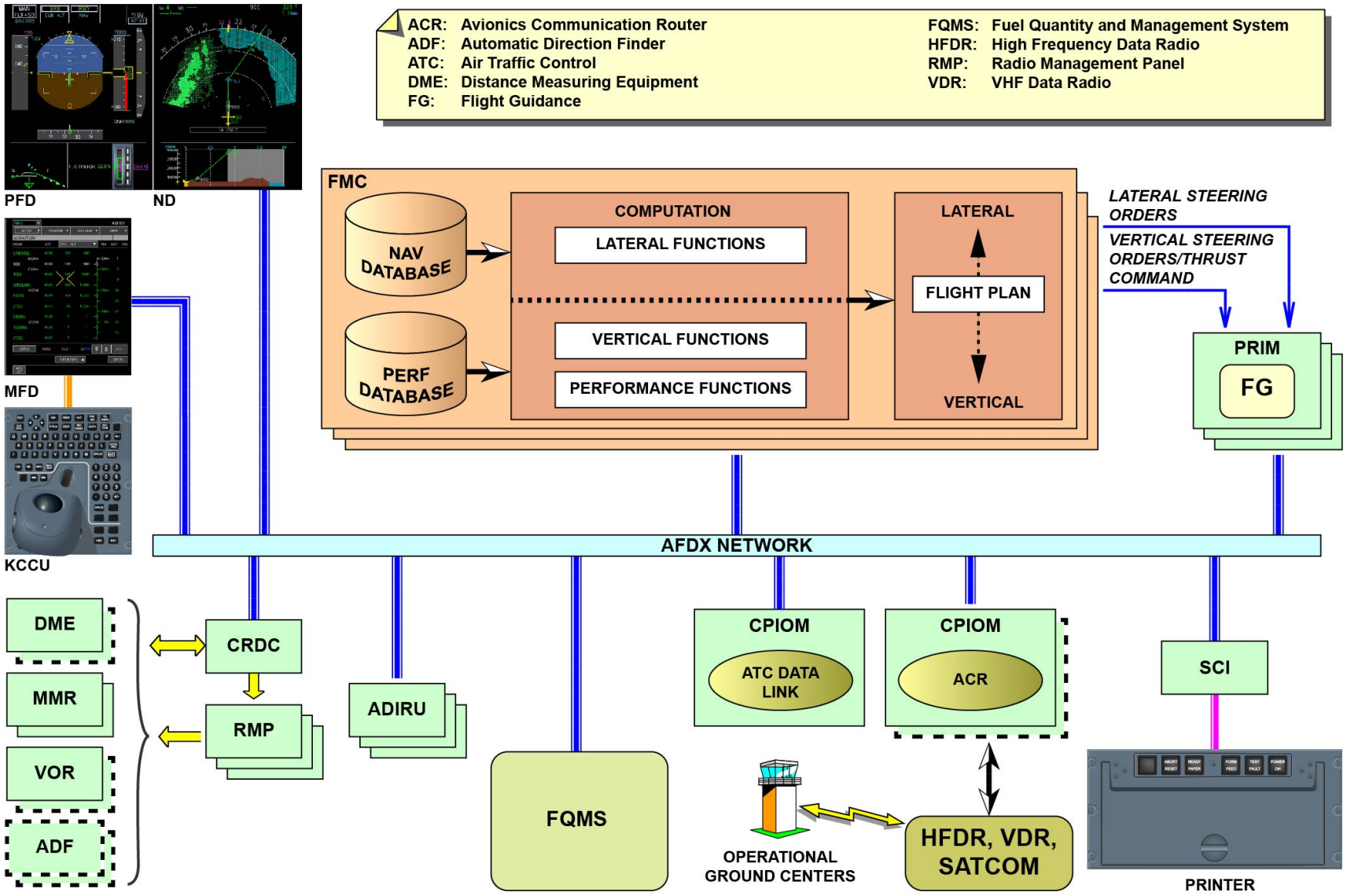

FLIGHT MANAGEMENT SYSTEM

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AUTO FLIGHT SYSTEM (AFS) CONTROL AND INDICATING (3)

A/P and FD Engagement/Disengagement Logics on Ground (3)

The conditions common to the AP and FD engagements on the ground are:
- One PRIM minimum in operation,
- Two Air Data Reference units (ADR) minimum are aligned.
- The FCU is in operation.
- The aircraft with all the engines stopped and with low hydraulic pressure.

The FD is automatically engaged at aircraft power-up, at engine start on the ground and in Go Around mode.
The pilots can engage the AP with the AP1 and/or AP2 keys of the FCU.
The APs are engaged one at a time but dual AP engagement is possible in the Approach (APPR) and Go around (GA) modes.
When an AP is engaged:
- The three green bars of the AP key on the FCU are on,
- The side sticks are locked,
- The rudder pedals are locked.

The AP is disengaged if one of these conditions occurs:
- The AP1 and/or AP2 keys are released.
- The takeover and priority pushbutton switches are pushed.
- The side sticks are unlocked.
- The rudder pedals are unlocked.
- A fault is detected.
- One engine is started on the ground.
- The other AP is engaged (not in APPR).

The FD is disengaged if one of these conditions occurs:
- The FD key on the FCU is released.
- The aircraft gets to VLS
- The aircraft gets to Vmo/Mmo
- A fault is detected.

The status (engagement, activation) of the AP/FD modes is shown on the Flight Mode Annunciator (FMA). The FMA is divided into five sections.
For the longitudinal and lateral modes:
- The first line shows the mode active in green.
- The second line shows the mode armed in cyan and for target display when in selected mode.

In case of AP/FD disconnection, aural warning is broadcasted and attention getters are used to warn the flight crew.

A/THR Manual Engagement/Disengagement on Ground (3)

The A/THR is manually engaged when the A/THR key located on the Flight Control Unit (FCU) is pushed (or with the FCU backup if there is a FCU fault).
The A/THR is disengaged if one of these conditions occurs:
- One of the two A/THR instinctive disconnect pushbutton-switches located on the throttle control levers (engines 1 or 2) is pushed
- The throttle control levers are set to the IDLE position.
- The A/THR key of the FCU is pushed (or through the FCU backup if there is a FCU fault),
- The two thrust reverser control-levers are set to one of the two REVERSE positions.

Messages related to the A/THR are shown on the Flight Mode Annunciator (FMA):
- The right column shows the engagement status.
- The left column shows different A/THR modes and the necessary operations.

In case of A/THR disconnection, aural warning is broadcasted and attention getters are used to warn the flight crew.
NOTE: When the A/THR is engaged, it can be active or inactive. If the A/THR is active, it manages the thrust. If the A/THR is not active, the cockpit crews control the thrust through the throttle control levers.

Main FCU to Backup FCU Switching (3)

The FCU backup function is used if there is a fault of the main FCU.

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If an FCU fault is detected (AFS or EFIS control panel fault), the related FCU backup part (AUTOFLIGHT or EFIS page on the MFD) automatically changes back to the active mode.
The backup function keeps the settings of the FCU (no Pilot inputs are necessary).
In the active mode, the Pilots can change the current modes and settings only on the AUTOFLIGHT and EFIS pages of the MFD. If they select modes, targets or settings directly on the FCU, there will be no effect and no data will be shown on the FCU display windows.
If no FCU fault is detected, it is possible to force the active mode as follows:
- Switch off the FCU with the potentiometers included in the center light of the main instrument panel or
- Select the applicable toggle button (on the AUTOFLIGHT or EFIS page). The related FCU part (AFS or EFIS control panel) is then automatically switched off (except panel lighting).

When the FCU is switched OFF, attention getters and ECAM warning are used to alert the pilots.
After you use the FCU backup function and when you switch on again the FCU, the main settings are restored on the FCU.

FMC Faults (3)

The FMS operates in different modes: Dual, Independent, Single and Standby.
Dual mode
Two FMCs (one for the display on the Captain side and the other for the display on the F/O side) operate in Dual mode. The two FMCs make their computation independently and exchange different data for the synchronization.
FMC-A supplies FMS 1; "FMS 1" indication.
FMC-B supplies FMS 2; "FMS 2" indication.
The Master FMC (which supplies data for Flight Guidance) is:
- FMC-A if AP 1 is engaged (or no AP engaged)
- FMC-B if AP 2 is engaged

Independent mode
The FM automatically sets to independent mode if the configuration is not correct (data base or operational software) between the two FMCs that operate in dual mode or if a cross-talk failure occurs.
In this mode, each FMC operate without synchronization.
Single mode
The FM operates in single mode when one FMC drives the display on the CAPT and F/O sides.
Standby mode
The third FMC is a standby unit operated automatically if there is a failure of the Master FMC or the Slave FMC.
Reconfiguration
If a failure of the second FMC occurs, the first FMC drives the display on the CAPT and F/O sides (single mode operation) after a manual reconfiguration (crew action).

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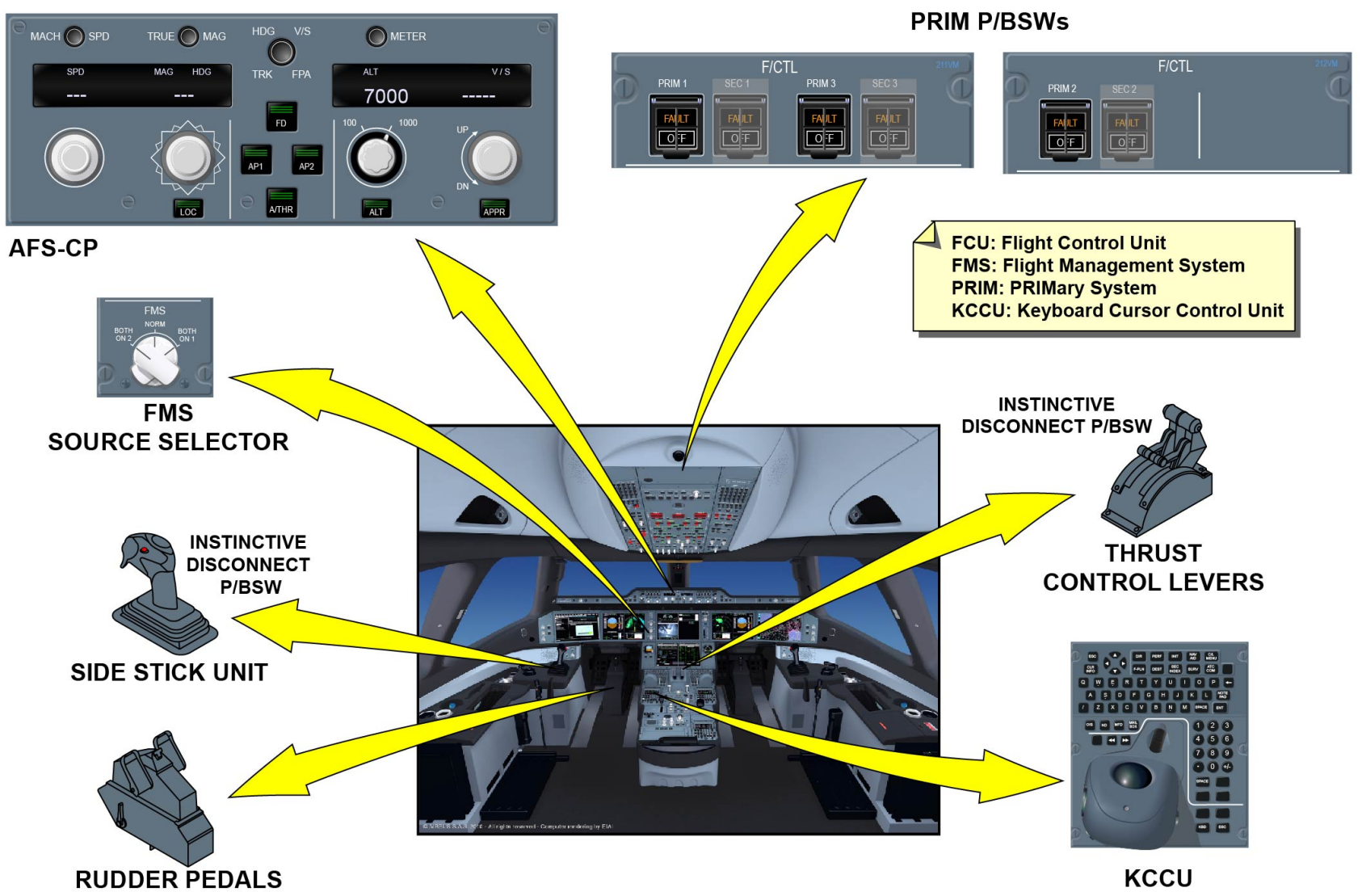
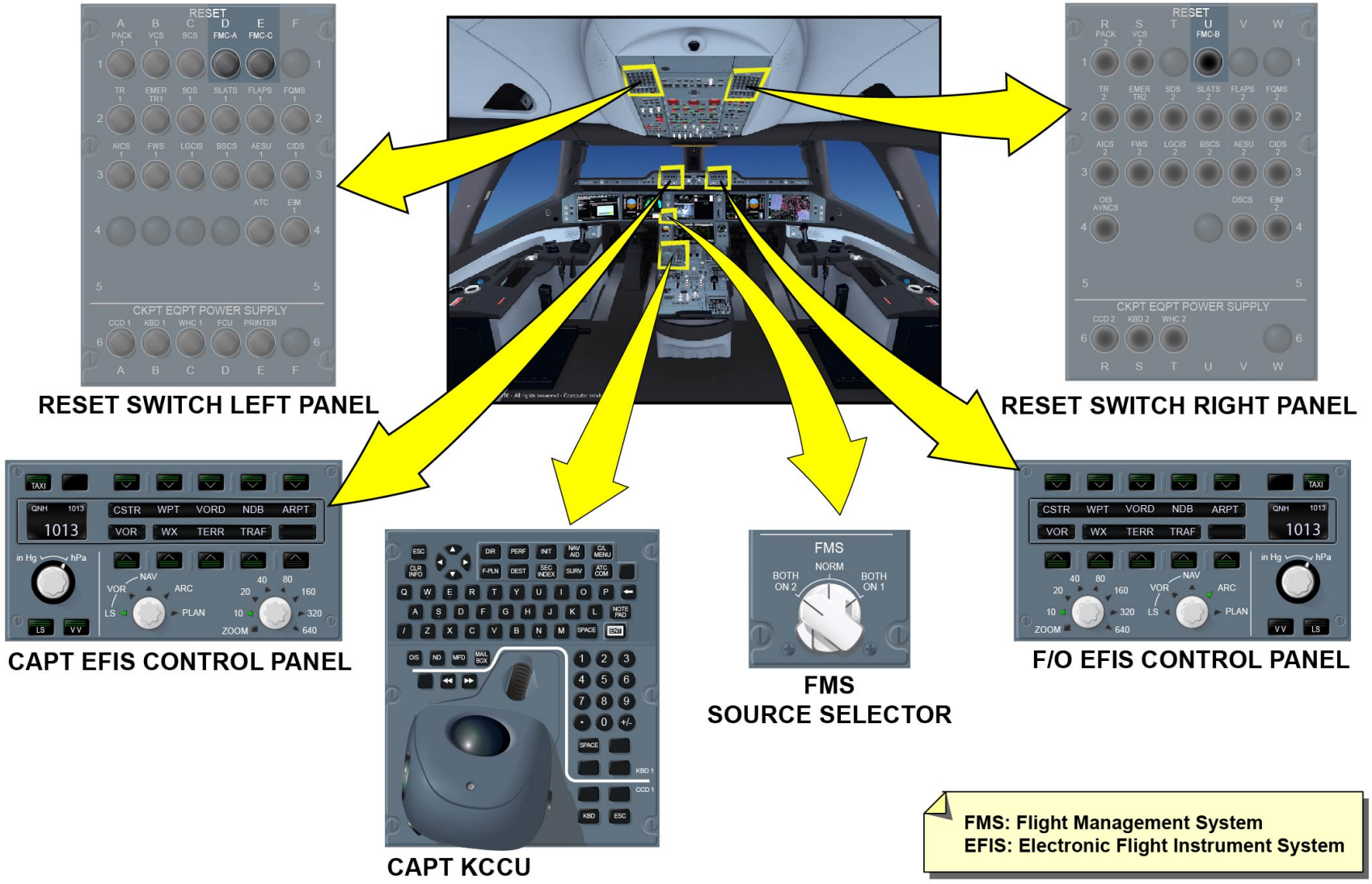


A/P AND FD ENGAGEMENT/DISENGAGEMENT LOGICS ON GROUND (3) ... FMC FAULTS (3)



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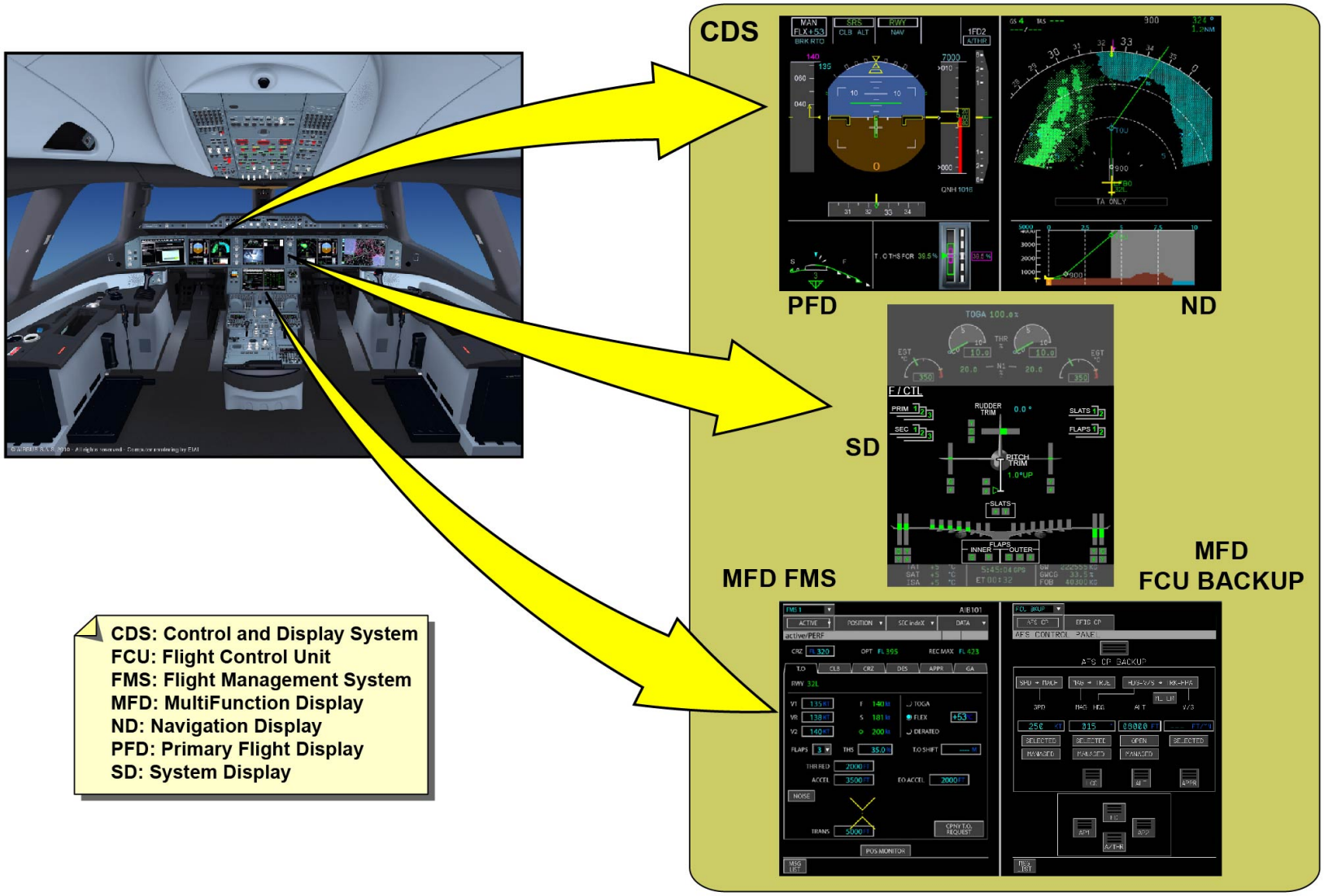

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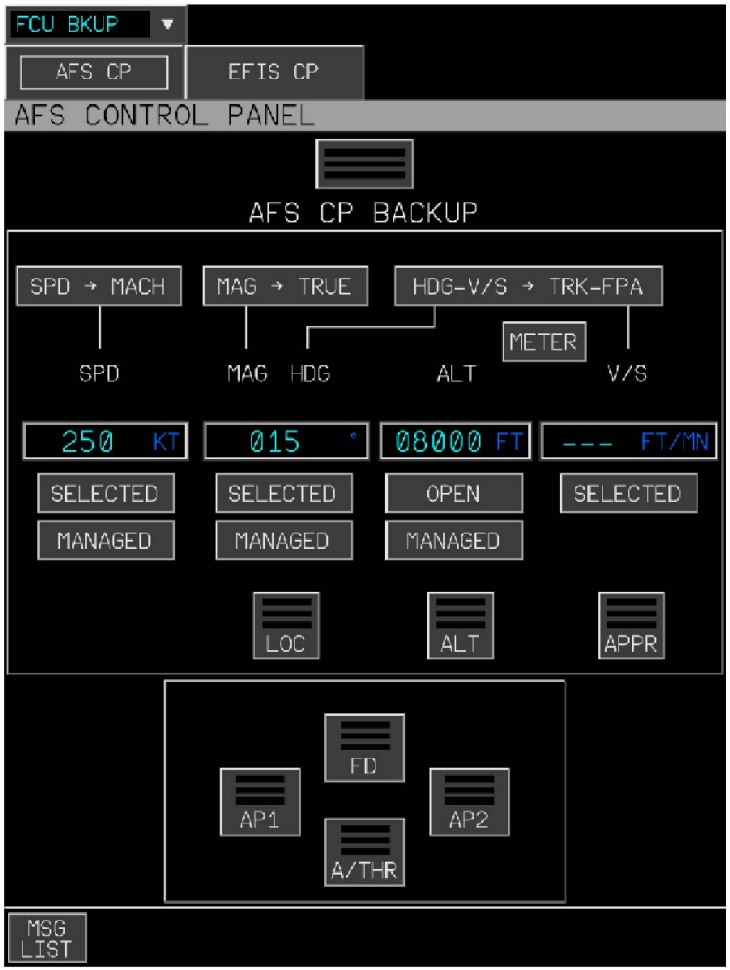

MFD FCU BACKUP PAGE - AFS CP TAB

A/P AND FD ENGAGEMENT/DISENGAGEMENT LOGICS ON GROUND (3) ... FMC FAULTS (3)

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